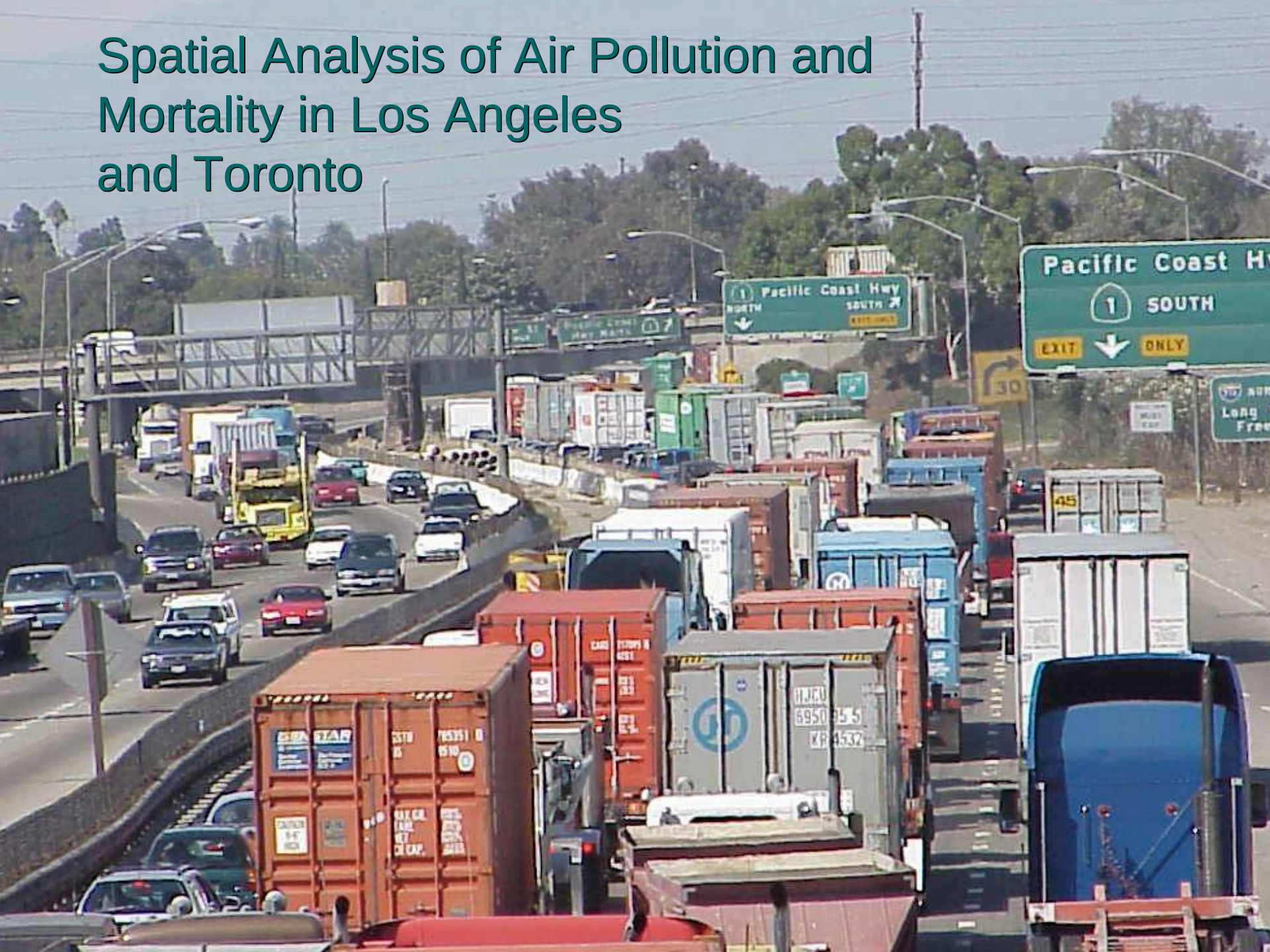
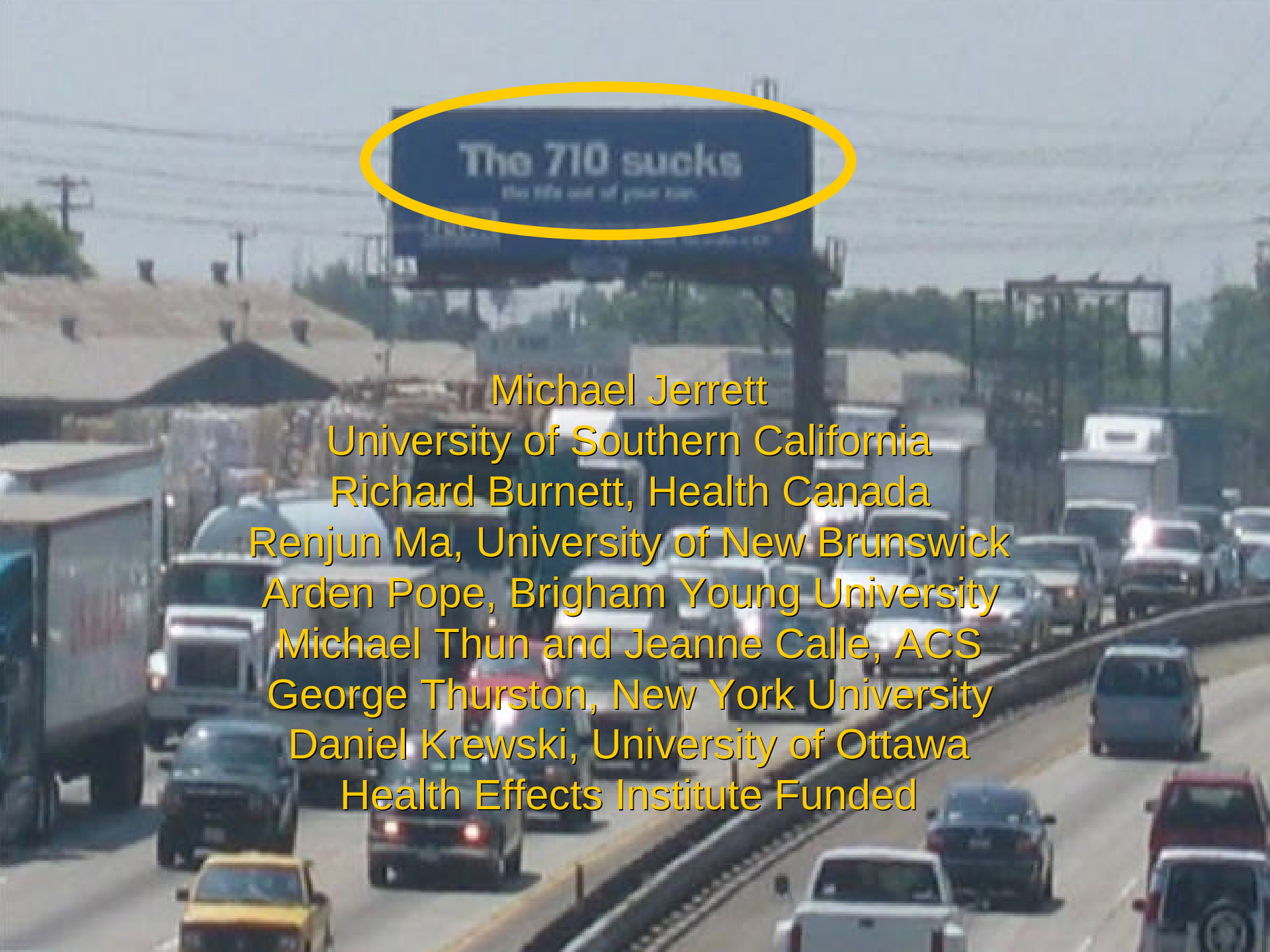
Spatial Analysis of Air Pollution and Mortality in Los Angeles and Toronto





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Background

- **Intra-urban gradients in air pollution exposure are large and may exert significant health impacts**
- **Research in Europe found 60-95% elevation in cardio-pulmonary mortality from intra-urban exposure (Hoek et al. 2002; Nafstad et al. 2004)**
- **Similar findings reported in a Canadian cohort (Finkelstein, Jerrett et al. 2003, 2004)**
- **No comparable evidence in the US or using $PM_{2.5}$**

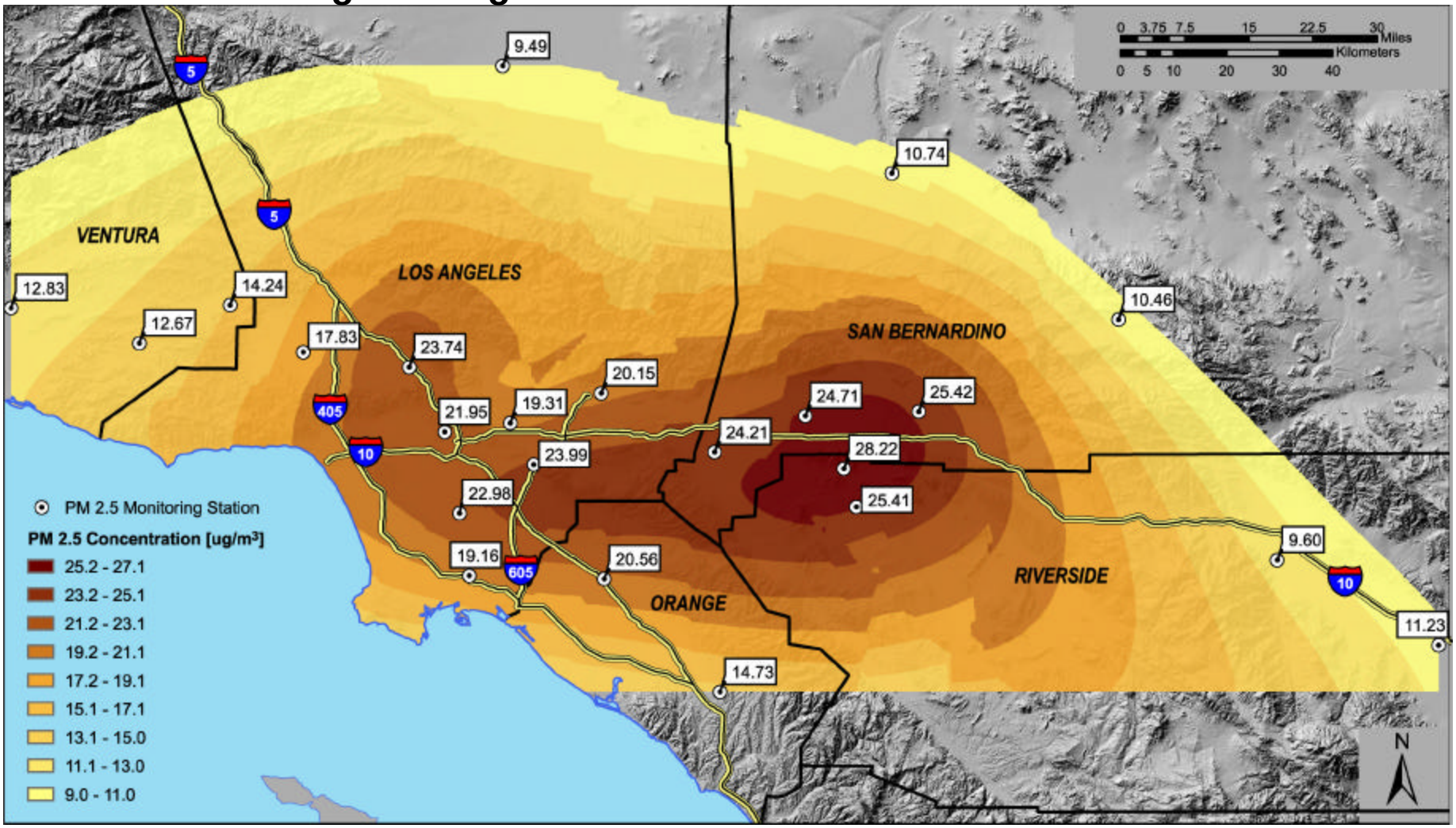
Research Questions

- Does intra-urban variation in exposure to fine particles associate with mortality in Los Angeles?
- If an association exists between air pollution and mortality, is it robust to alternative methods and confounders?

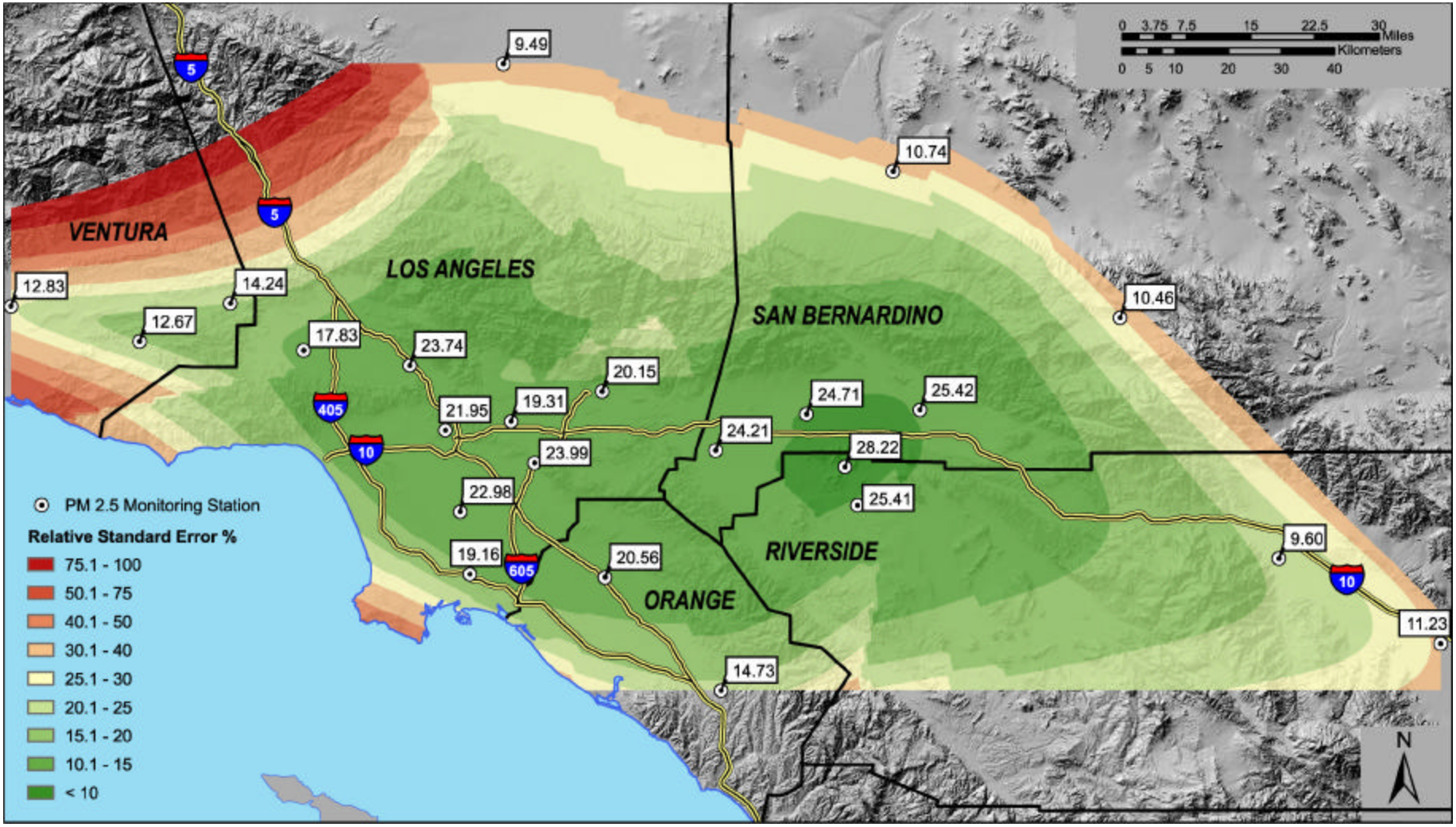
Data and Methods

- American Cancer Society cohort of 23,065 individuals enrolled in 1982 with 5856 deaths by 2000
- Zip code assignment of address (267 zips)
- Pollution surface interpolated from 23 stations with kriging method for $PM_{2.5}$ and 42 stations for ozone
- Control applied for 44 individual and 8 ecologic confounders in multilevel Cox models

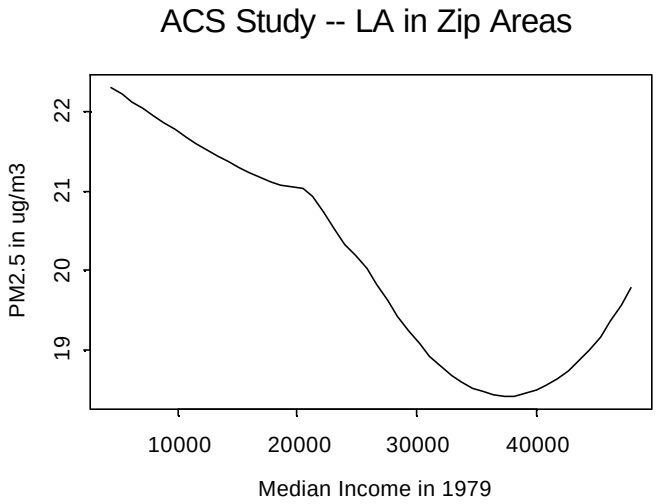
Modeled PM2.5 Concentration Levels throughout the Los Angeles Region

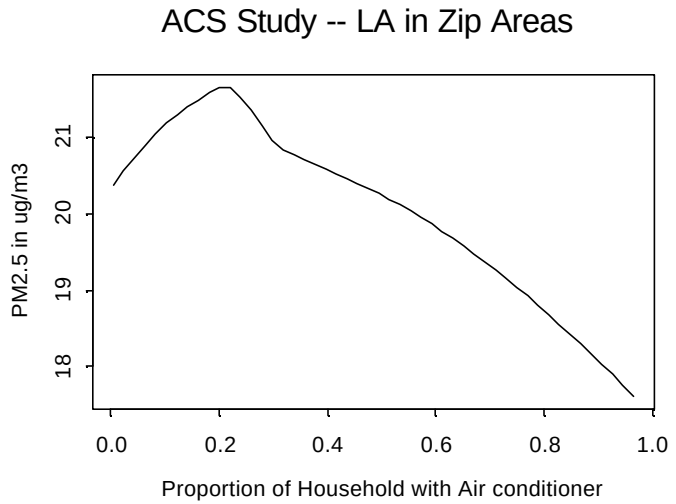


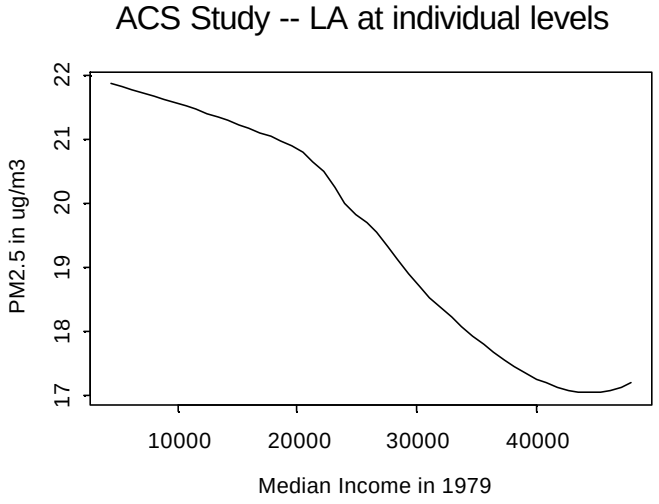
Standard Errors in Percentages

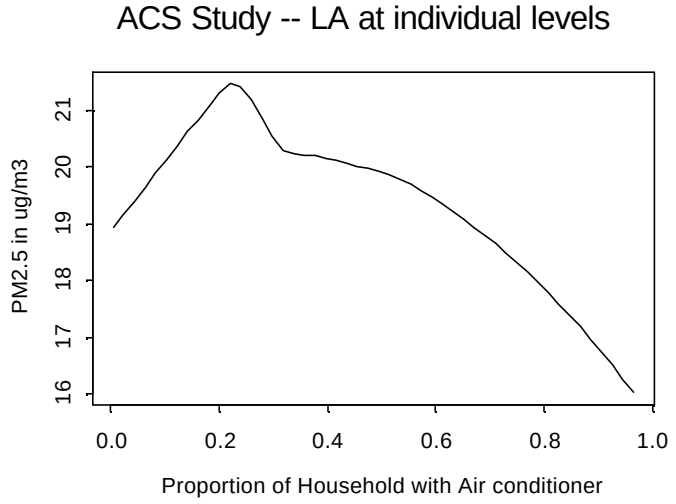


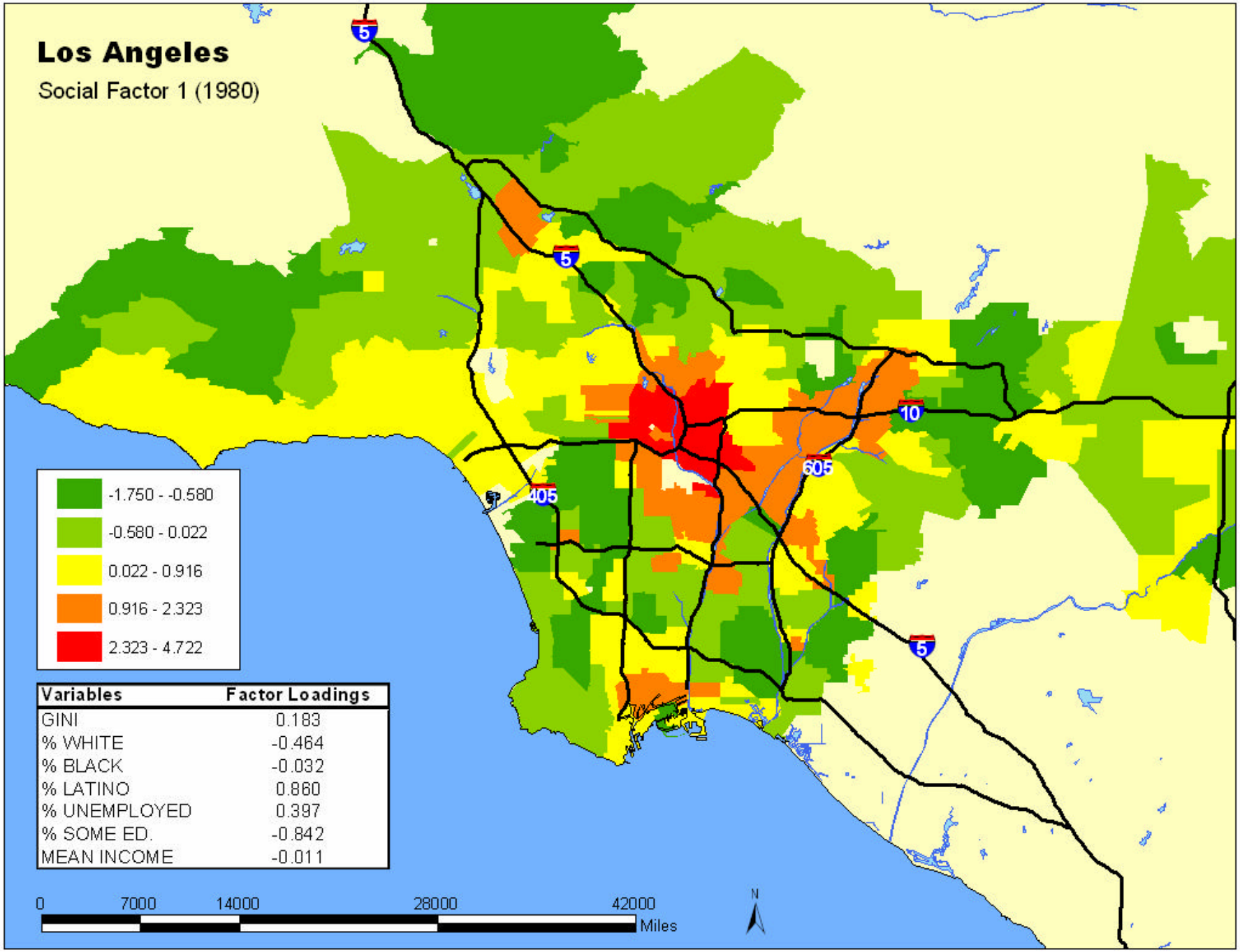
Wealth and Air Pollution Exposure







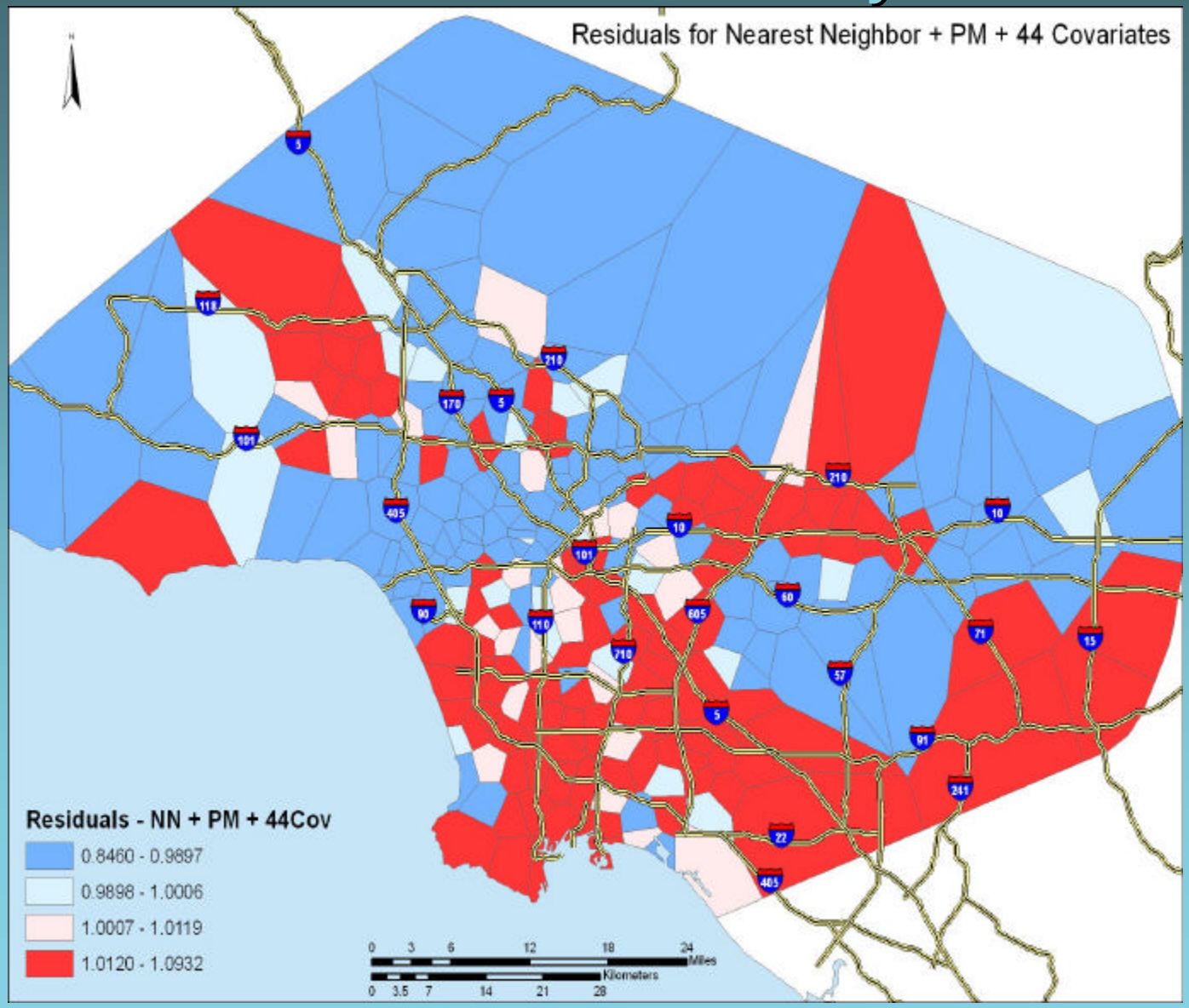



Los Angeles
Social Factor 1 (1980)
-1.750 - -0.580
-0.580 - 0.022
0.022 - 0.916
0.916 - 2.323
2.323 - 4.722
Variables | Factor Loadings
GINI 0.183
% WHITE -0.464
% BLACK -0.032
% LATINO 0.860
% UNEMPLOYED 0.397
% SOME ED. -0.842
MEAN INCOME -0.011
0 7000 14000 28000 42000
Miles
N
5
5
10
605
405
5

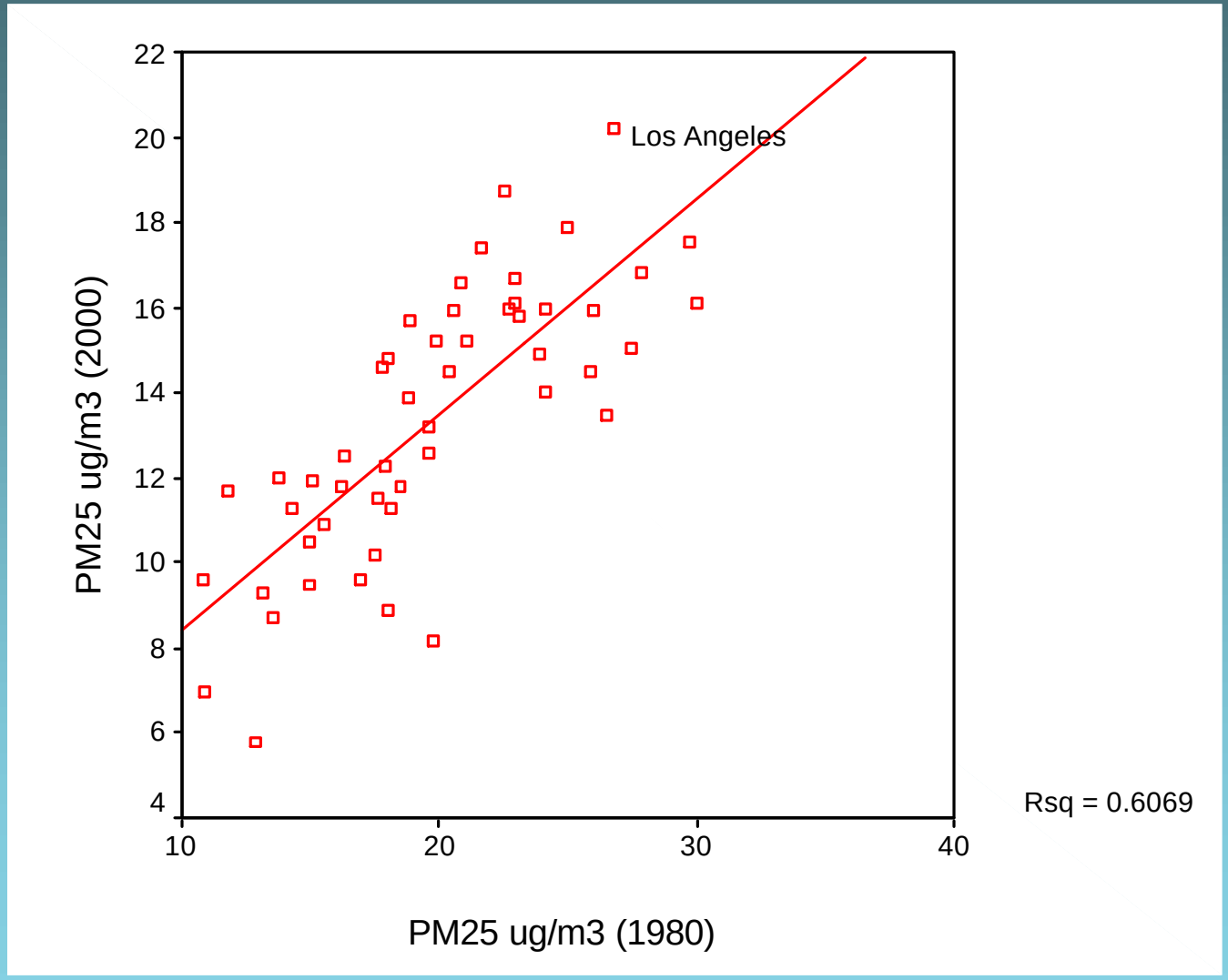
Results

- Pollution effects significant and large RR ~ 1.17 over 10 ug/m^3 contrast for all cause mortality (3 times as large as the inter-urban effect reported by Pope et al. 2002)
- Inclusion of confounders decreases effect to RR ~ 1.11
- Model appears robust to control for autocorrelation and random effects estimation
- Lung cancer and heart disease RR range from 1.25-1.60
- No ozone effect in any of the models

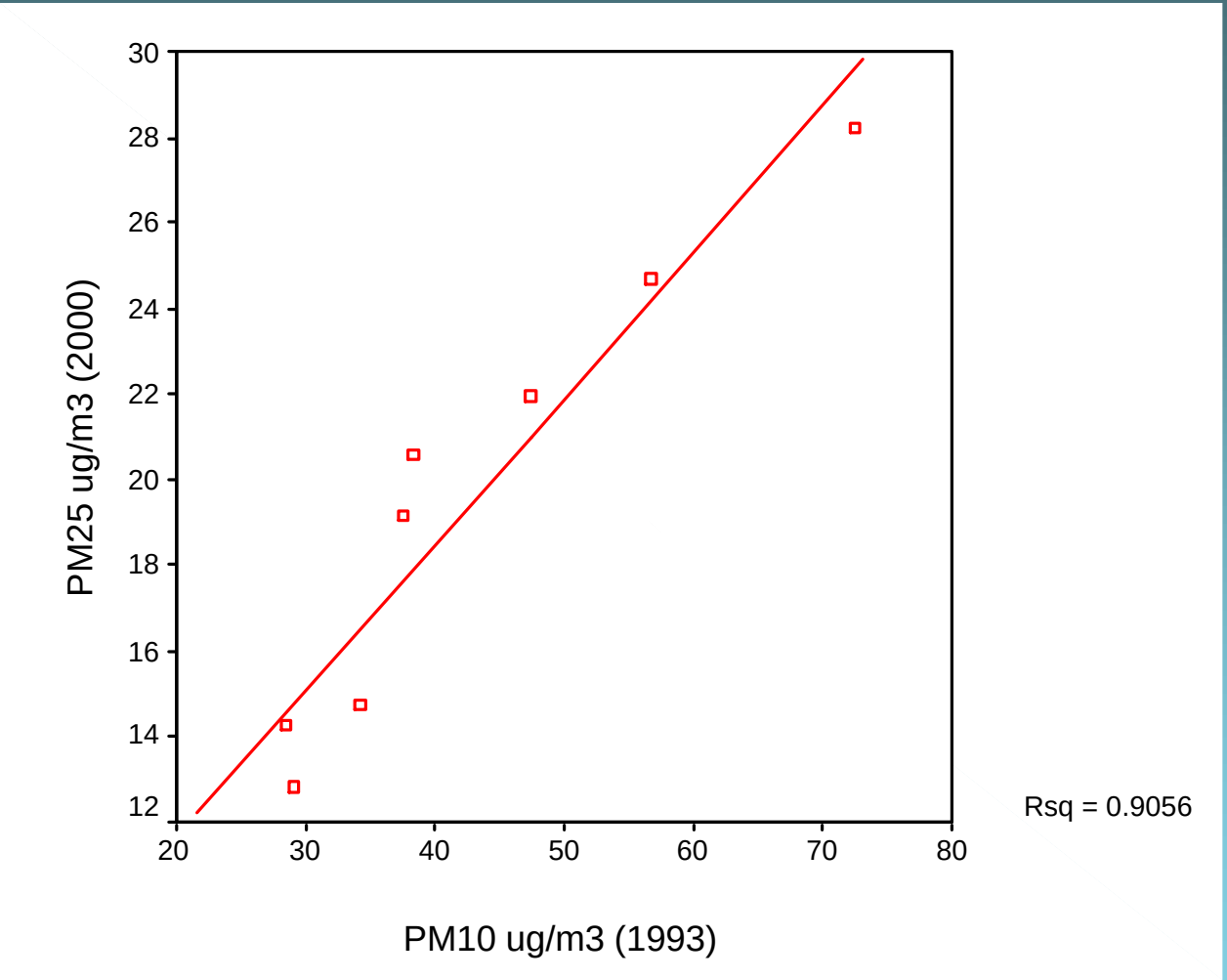
Residual Random Effects for All Cause Mortality



2000 $PM_{2.5}$ Regressed onto 1980 $PM_{2.5}$ (N = 51 Cities)



2000 $PM_{2.5}$ Regressed onto 1993 PM_{10} (N = 8 Sites in LA)



Future Directions

- More accurate assignment of residence
- Enhanced exposure models with traffic data, land use regression, GLM and co-pollutant models
- Comparison with NYC
- Assessment of retrospective exposure

Spatial Analysis of the Relation between Traffic-generated Air Pollution and Mortality in Toronto

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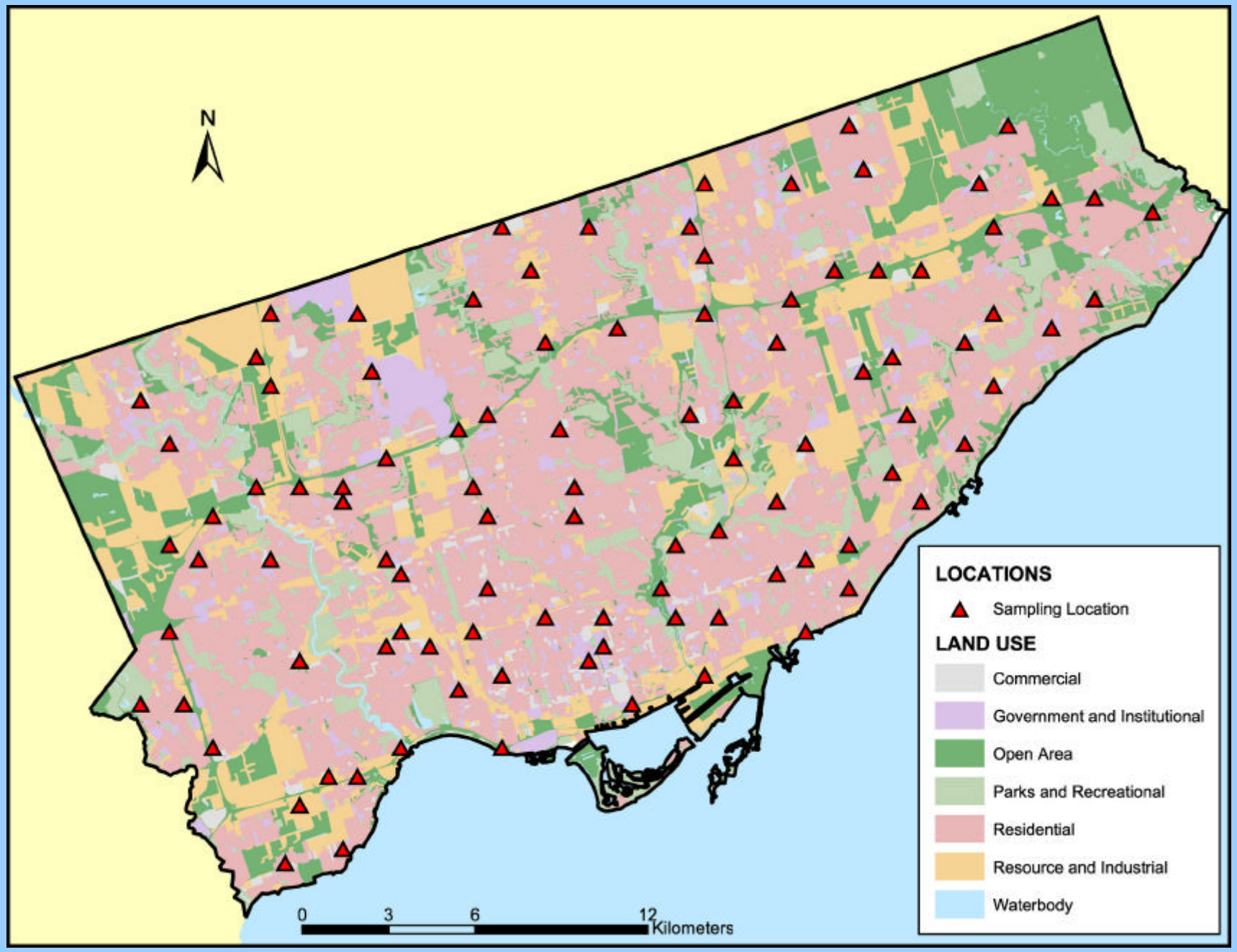
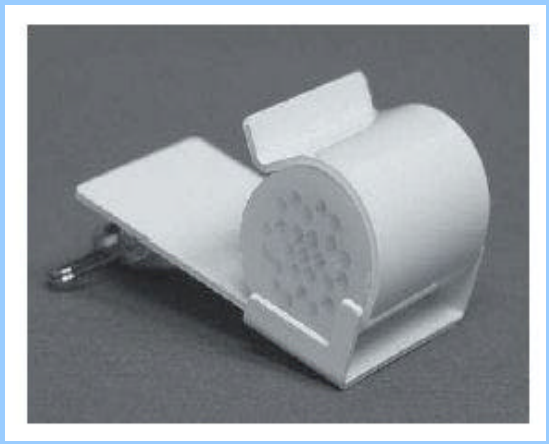
Research Objectives

1. To derive exposure assessments using land use regression techniques

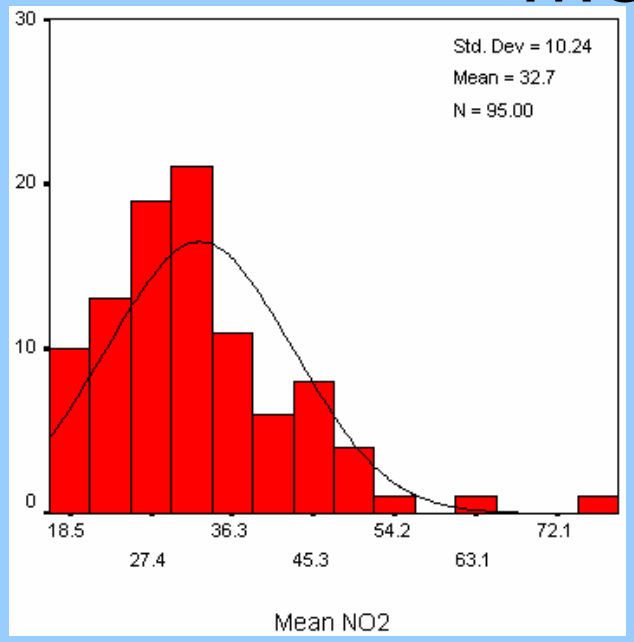
2. To test associations between NO_2 (marker for traffic pollution exposure) and mortality

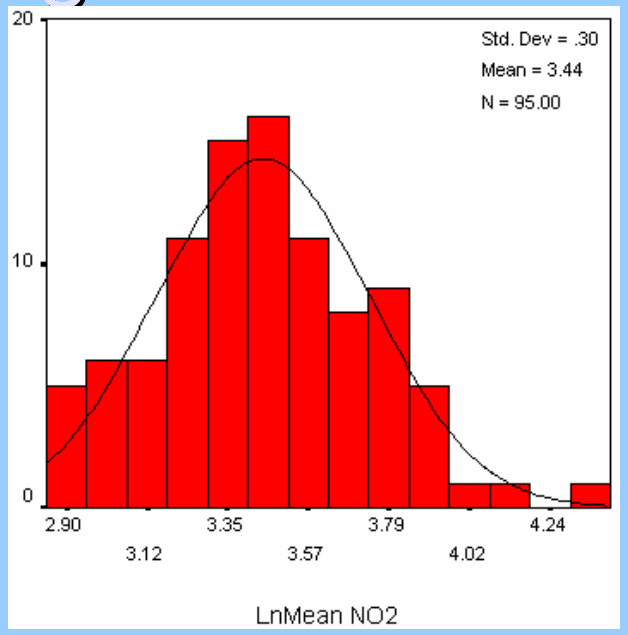

N
LOCATIONS
Sampling Location
LAND USE
Commercial
Government and Institutional
Open Area
Parks and Recreational
Residential
Resource and Industrial
Waterbody
0
3
6
12
Kilometers

Ogawa Passive Monitors



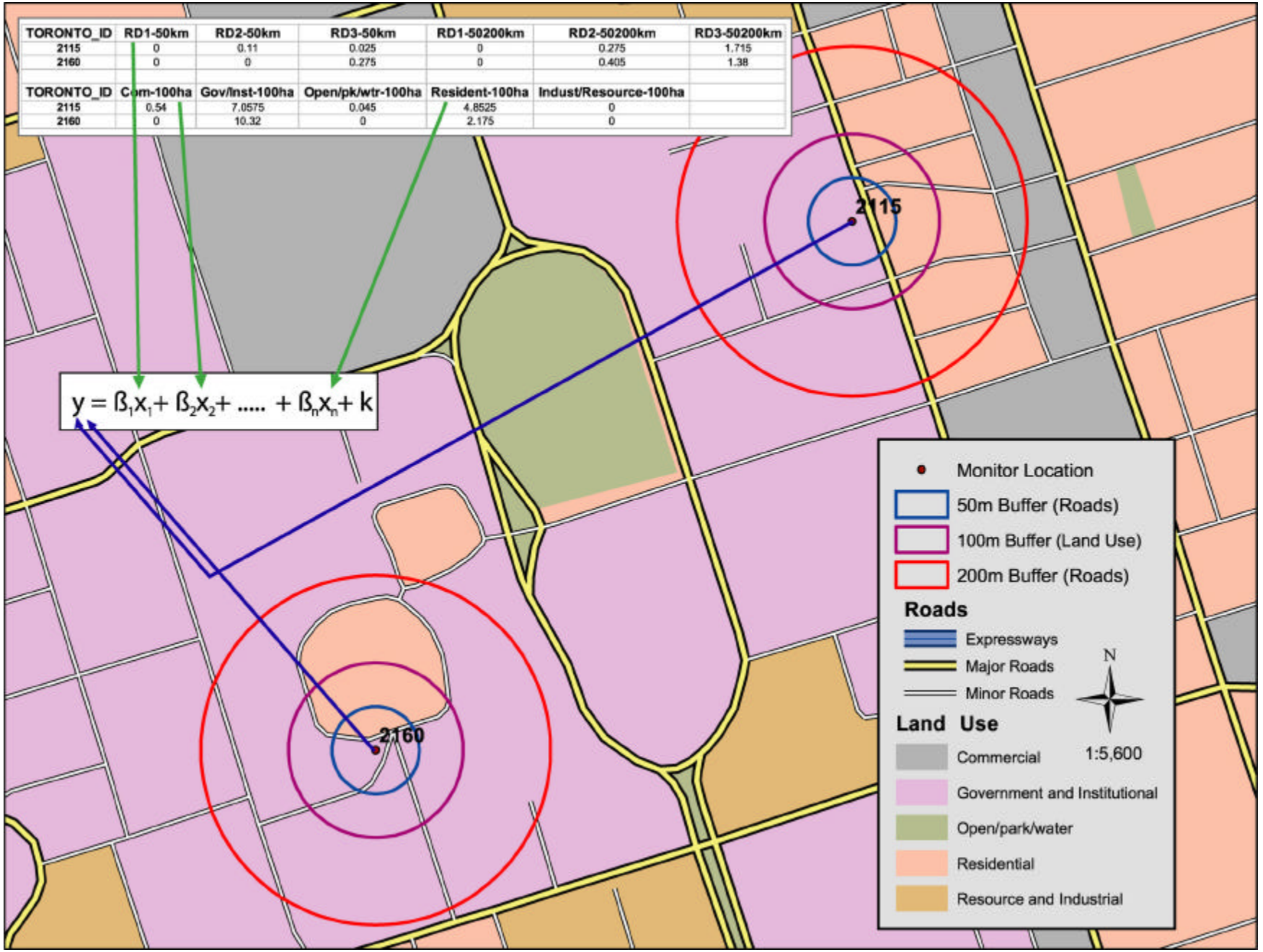
Results of the Field Monitoring



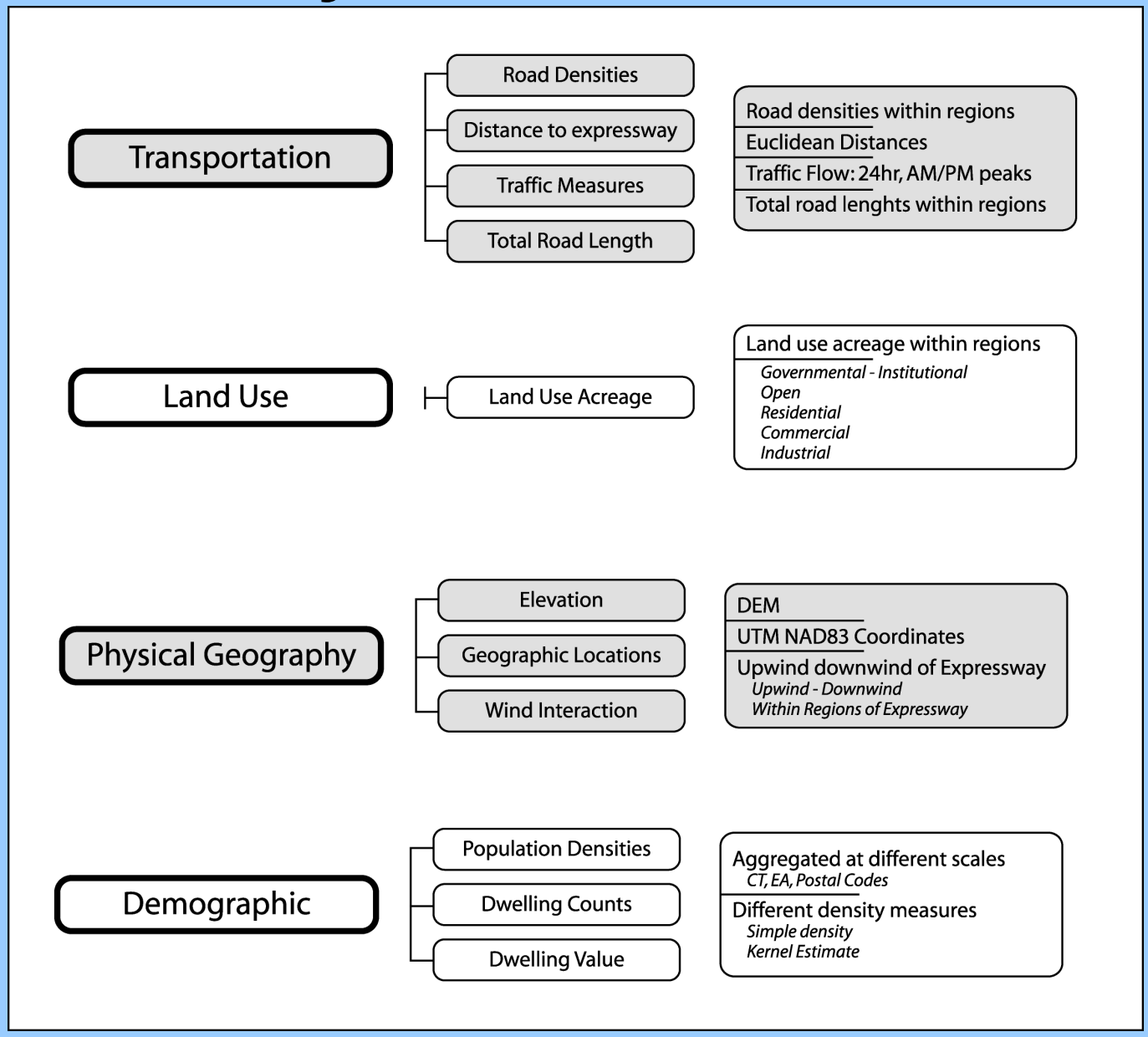


- **95 locations successfully retrieved in Sept 2002 and analyzed**

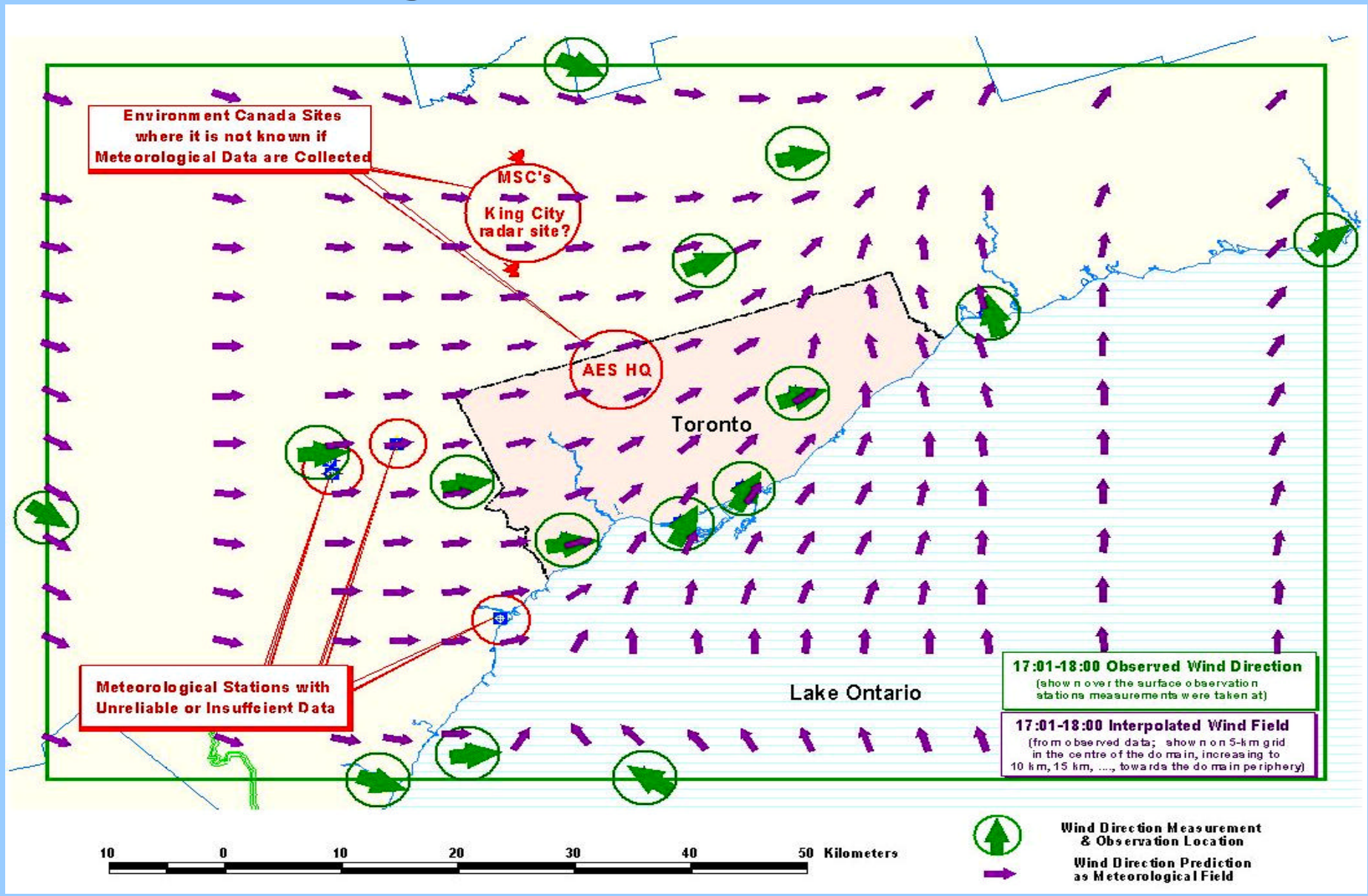
- **Range much larger than from Gov't monitoring**


TORONTO_ID RD1-50km RD2-50km RD3-50km RD1-50200km RD2-50200km RD3-50200km
2115 0 0.11 0.025 0 0.275 1.715
2160 0 0 0.275 0 0.405 1.38
TORONTO_ID Com-100ha Gov/inst-100ha Open/pk/wtr-100ha Resident-100ha Indust/Resource-100ha
2115 0.54 7.0575 0.045 4.8525 0
2160 0 10.32 0 2.175 0
y = ß1x1+ ß2x2+ ..... + ßnxn+ k
2115
2160
Monitor Location
50m Buffer (Roads)
100m Buffer (Land Use)
200m Buffer (Roads)
Roads
Expressways
Major Roads
Minor Roads
N
Land Use
1:5,600
Commercial
Government and Institutional
Open/park/water
Residential
Resource and Industrial

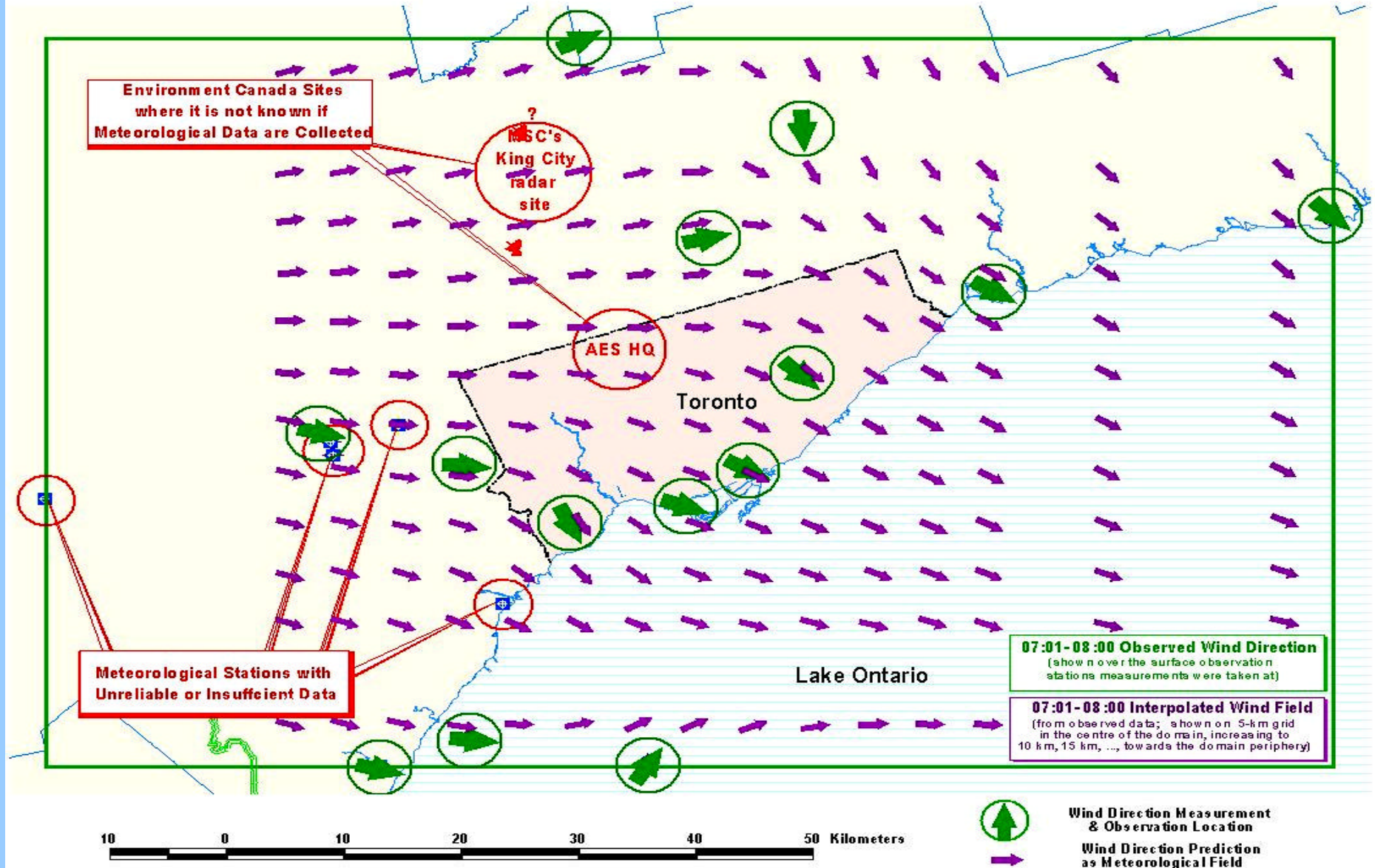
Summary of Variables Tested



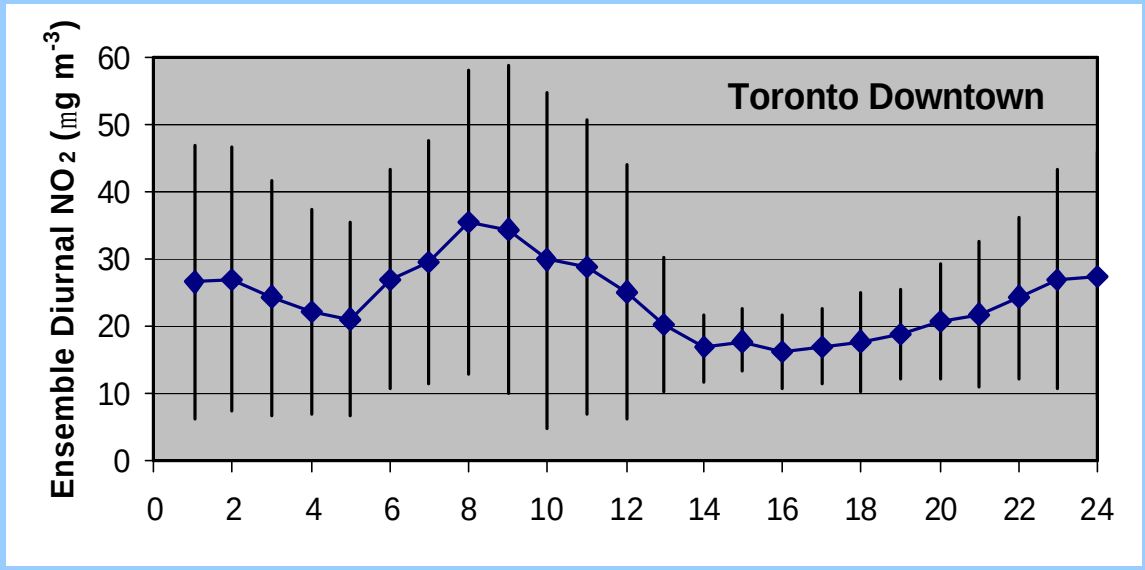
Evening Peak Wind Direction

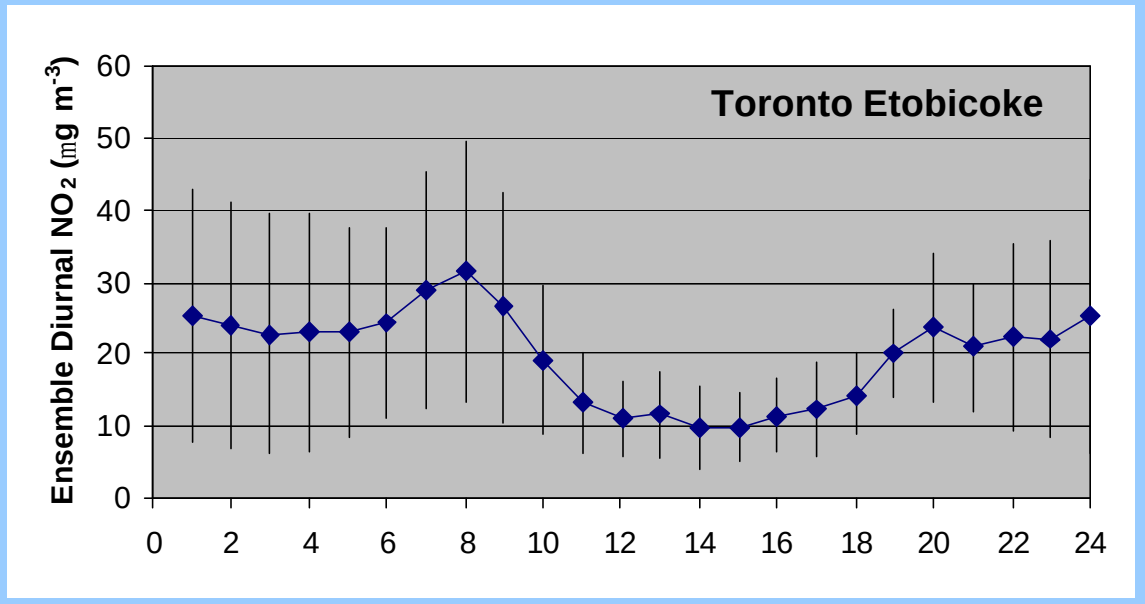


Morning Peak Wind Direction

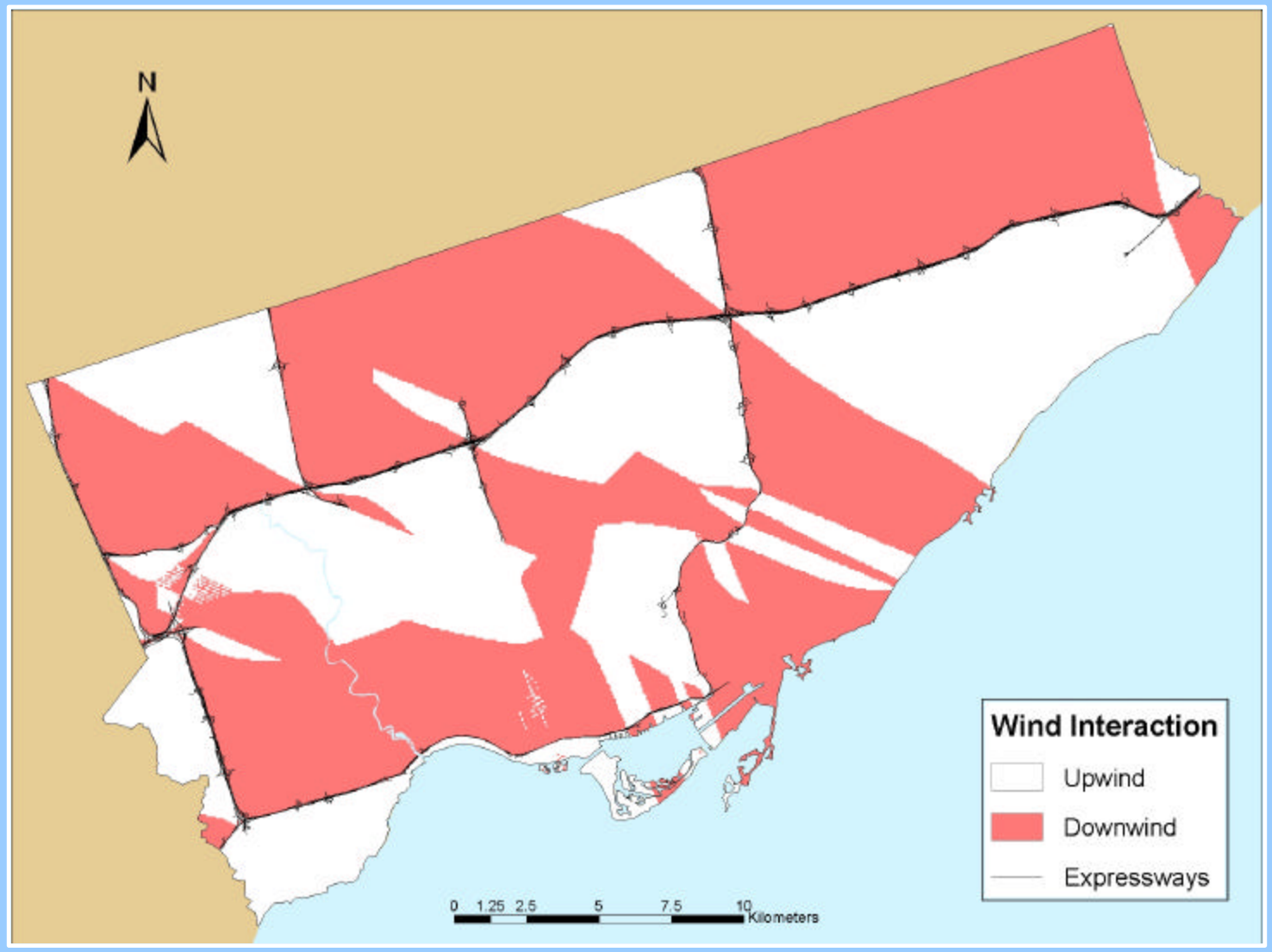


Diurnal Pattern in NO_2 Levels





Wind Direction Model



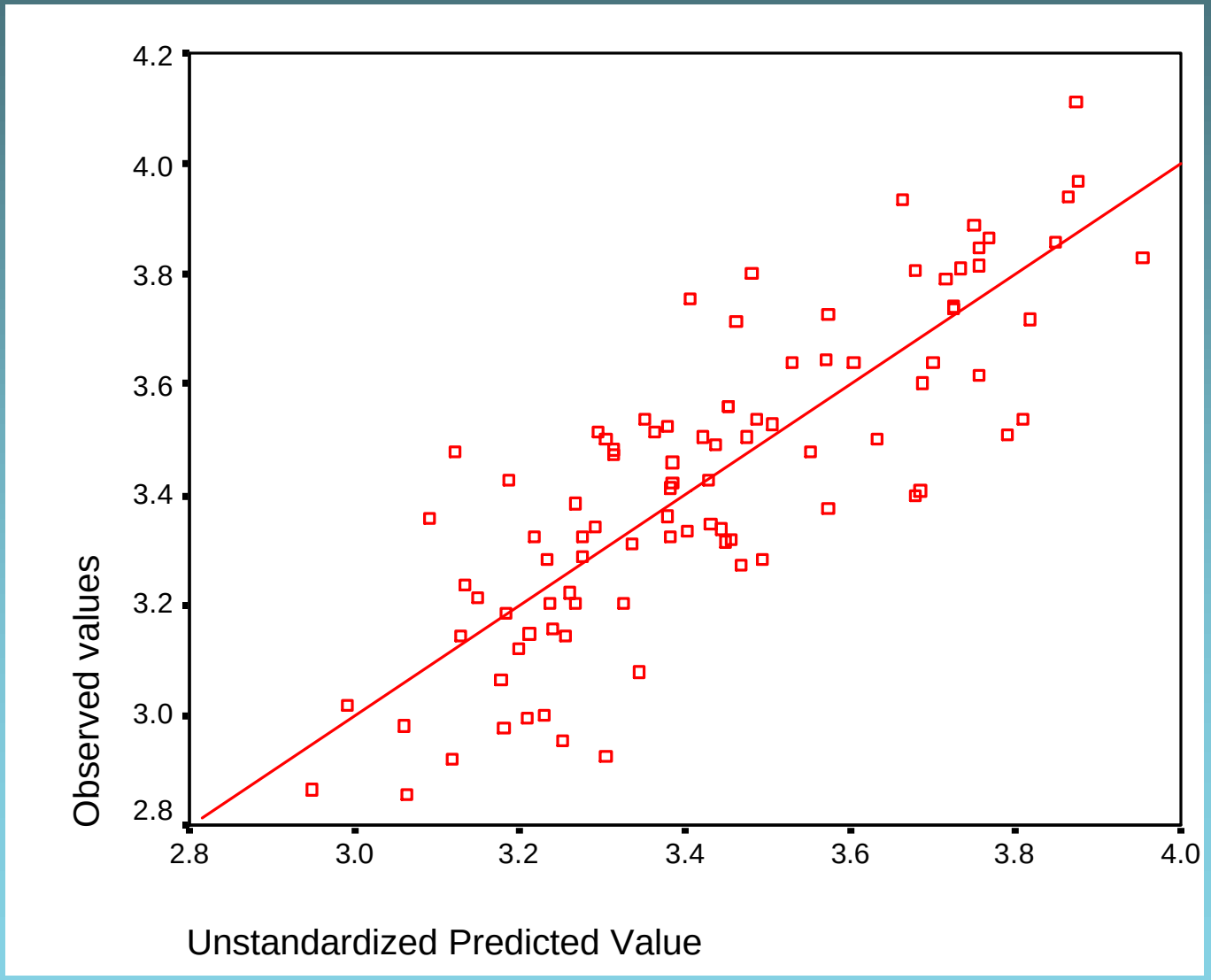
Model Summary

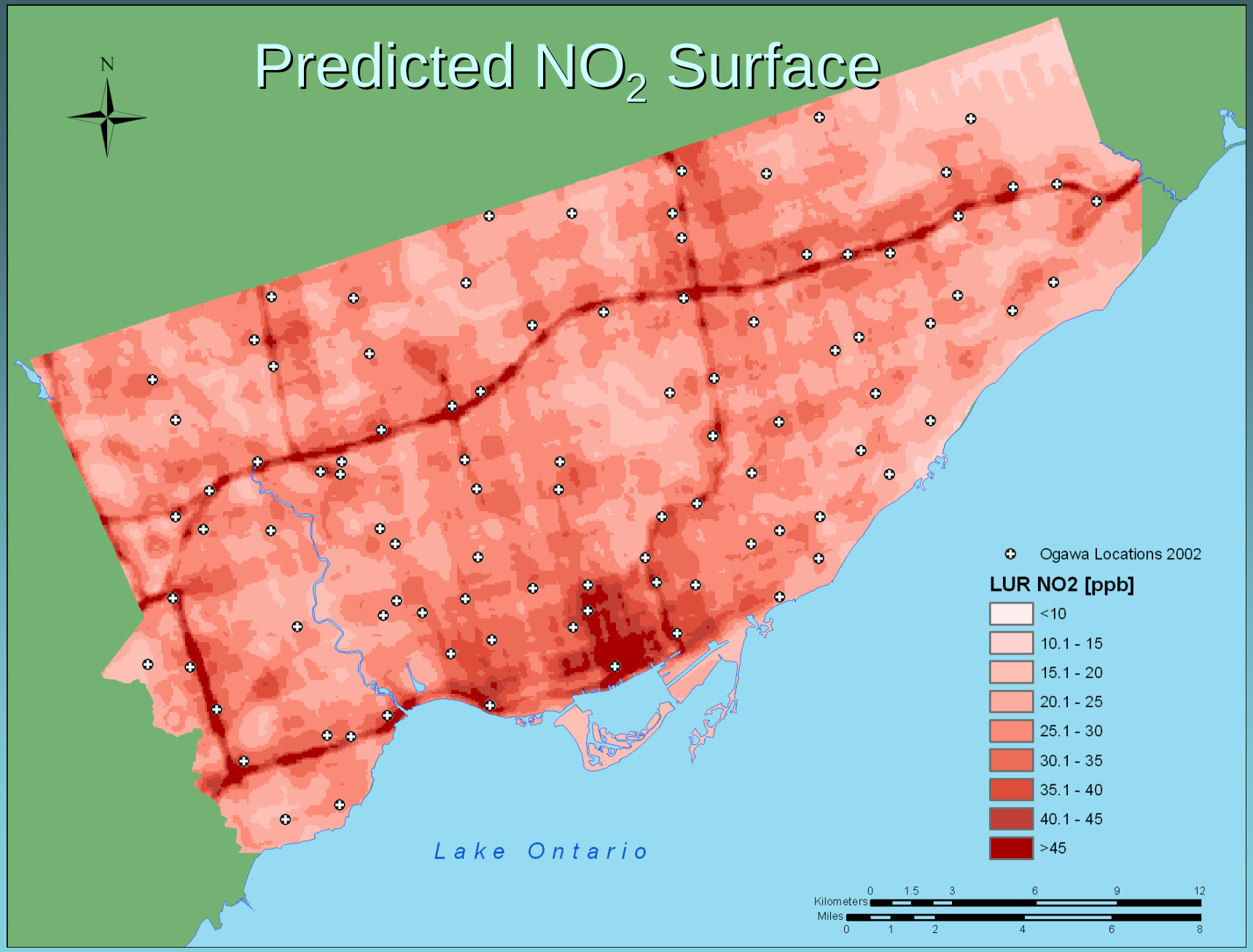
- $R^2 \sim 0.69$

Seven significant variables:

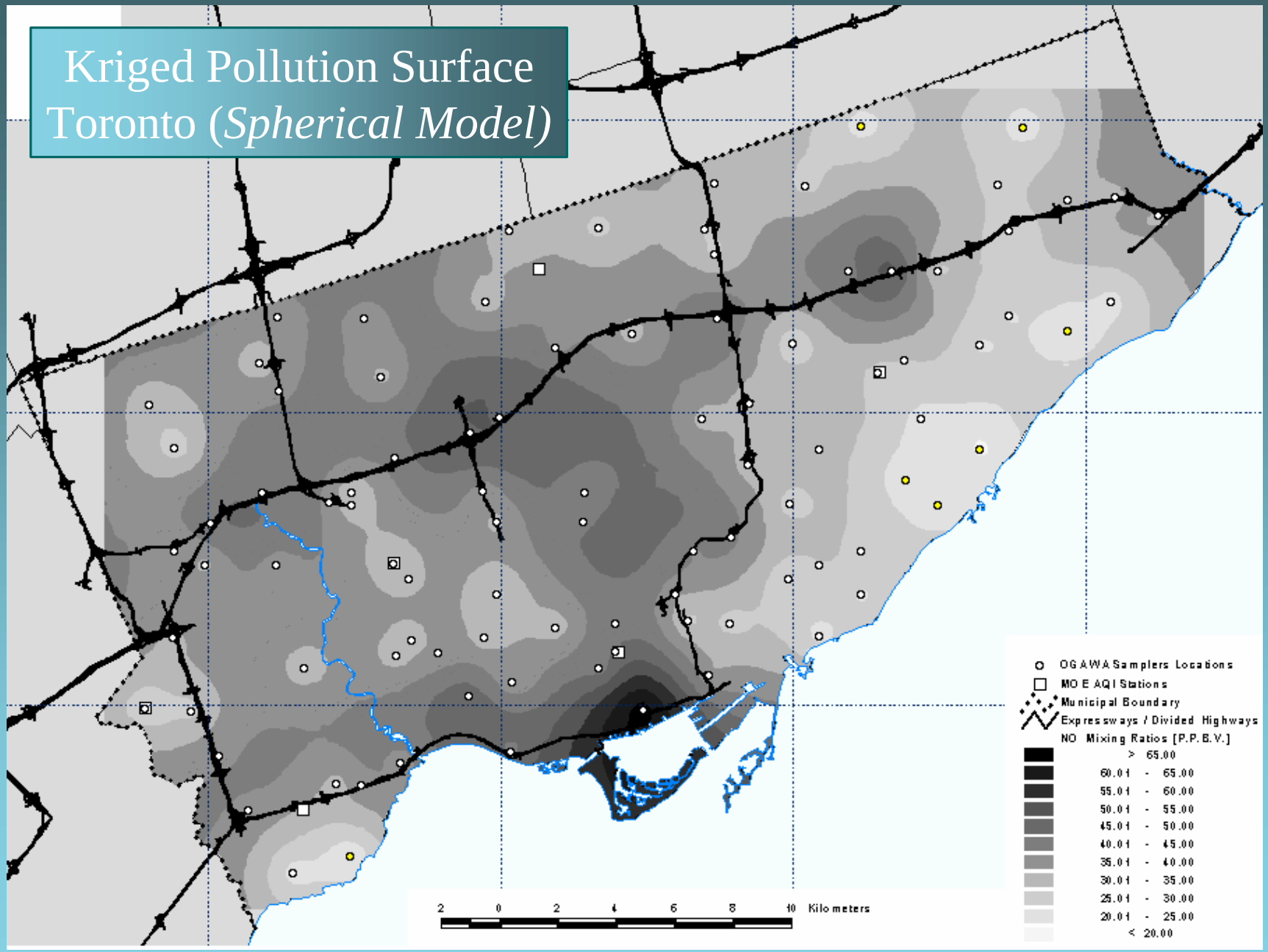
- Two measures of road length (+)
- Traffic density within 500 radius (+)
- Downwind with 1500 of expressway (+)
- Industrial land use (+)
- Dwelling counts within 2000 m (+)
- Longitude – West- East trend (-)

Observed on Predicted Values

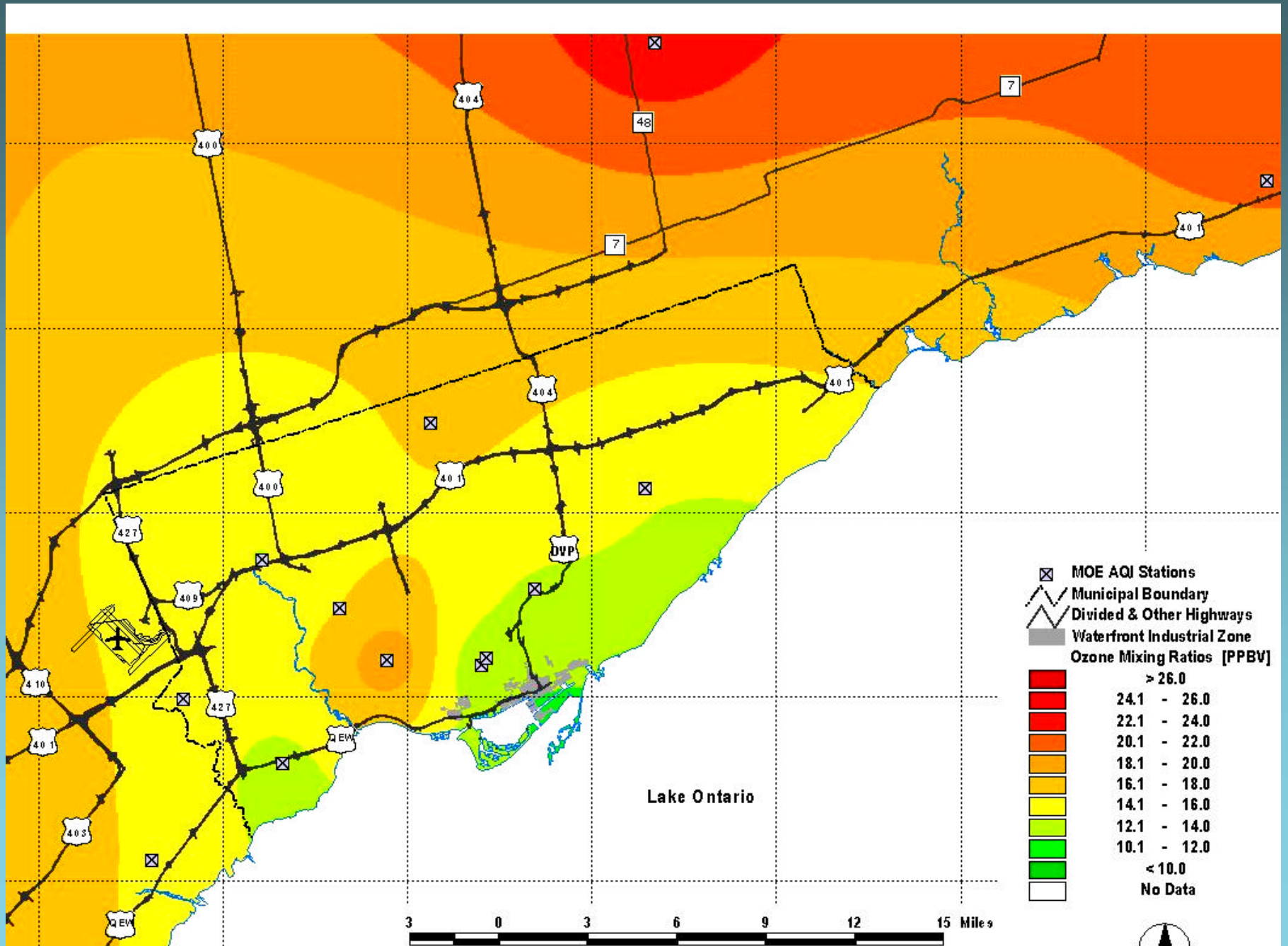



Predicted NO_2 Surface
N
Ogawa Locations 2002
LUR NO2 [ppb]
<10
10.1 - 15
15.1 - 20
20.1 - 25
25.1 - 30
30.1 - 35
35.1 - 40
40.1 - 45
>45
Lake Ontario
0 1.5 3 6 9 12
Kilometers
Miles
0 1 2 4 6 8

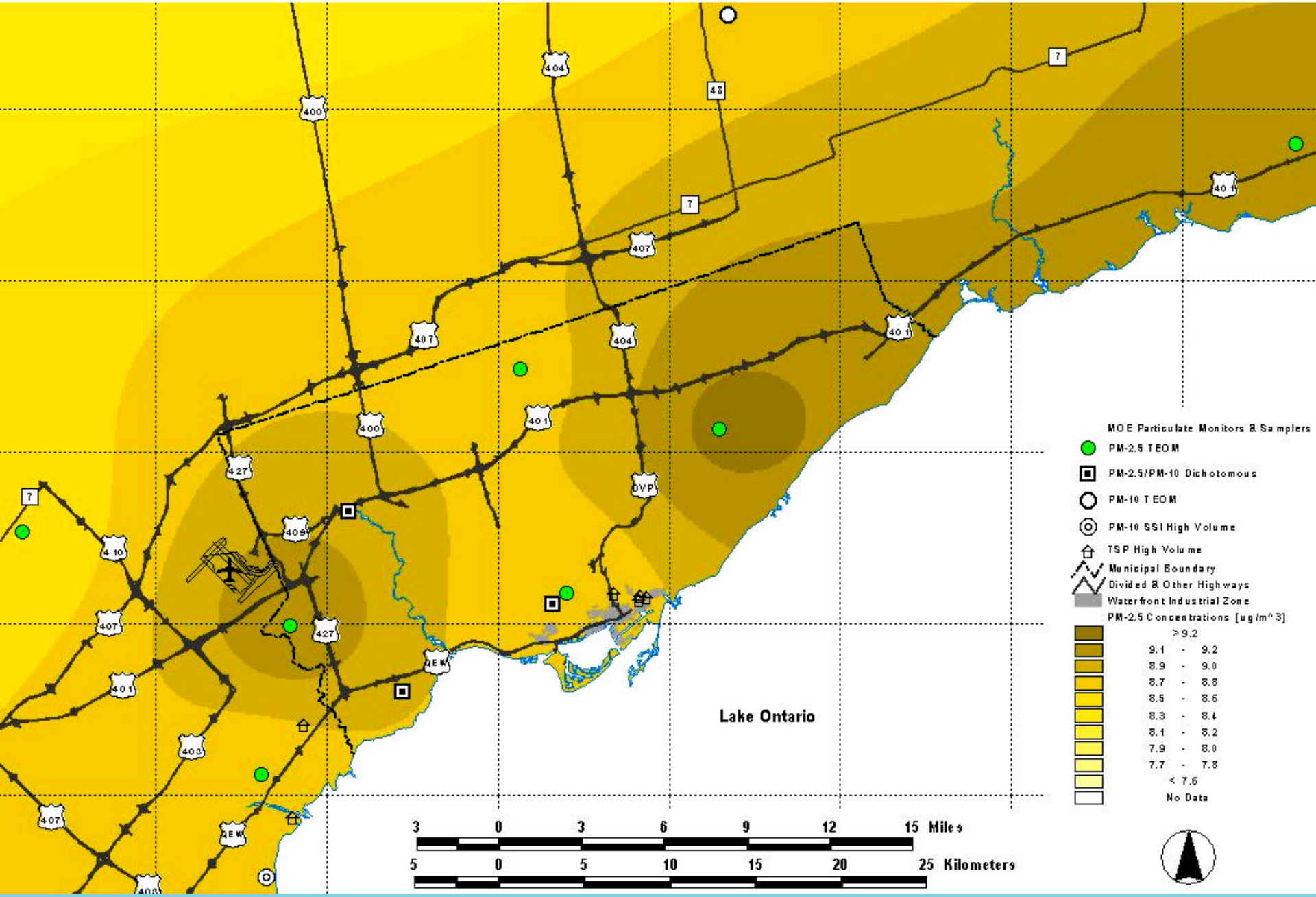
Kriged Pollution Surface Toronto (*Spherical Model*)



1992 Interpolated Ozone Levels in Toronto



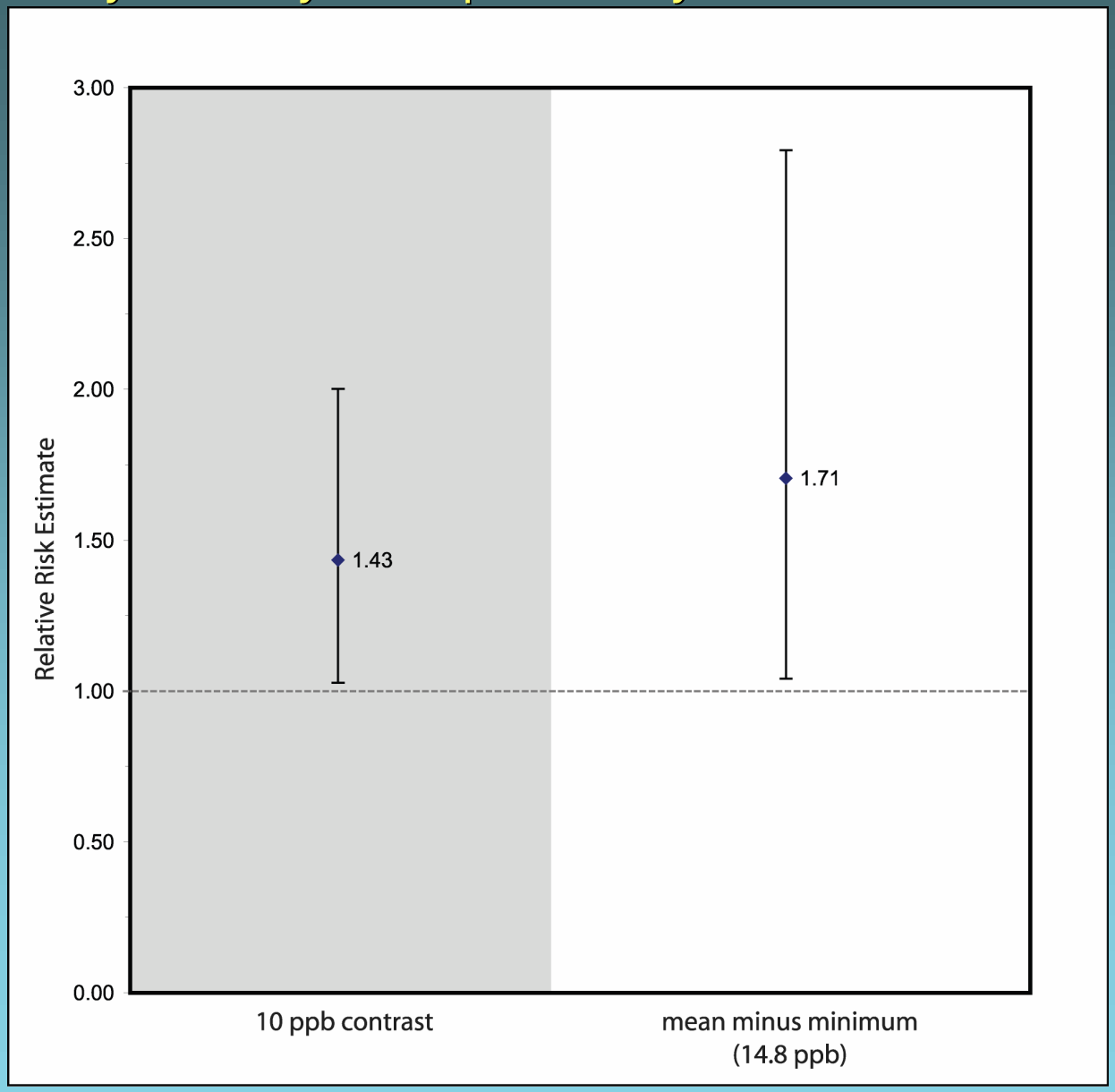
2002 Interpolated Fine Particulate ($PM_{2.5}$) Levels in the Greater Toronto Area



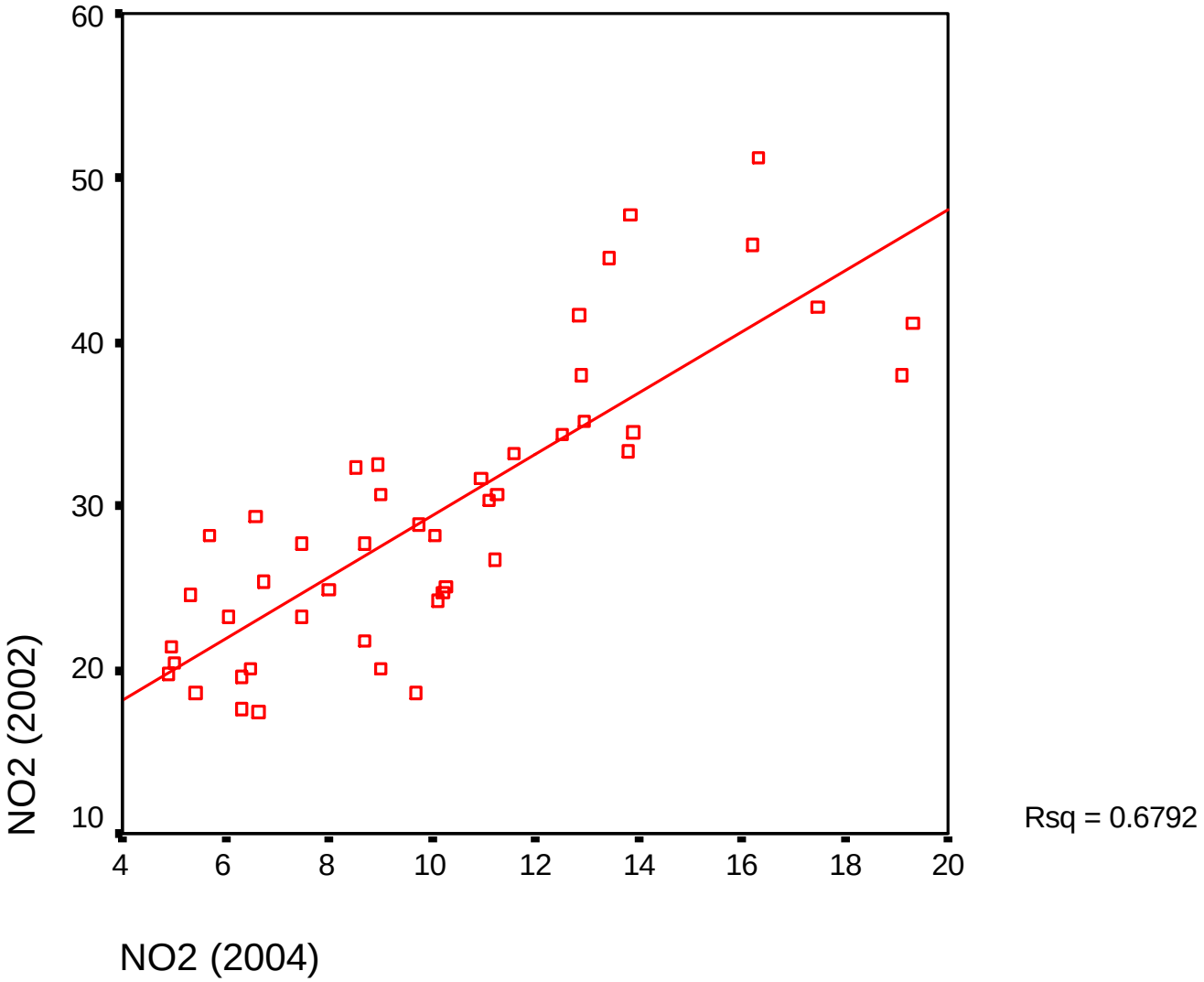
Cohort Assignment

- Assigned LUR exposure to 2401 patients from respiratory clinic in Toronto
- Mortality follow up from 1992-2002
- Health insurance billing (with medical diagnosis)
- Lung function tests
- Smoking info
- Neighborhood SES

RR Based on 10 ppb and 17 ppb (mean minus min) Contrast for Circulatory Mortality: Note preliminary results not for citation



Seasonal Correlation (Fall 2002 vs. Spring 2004)



Discussion

- Health effects from more robust exposure models larger
- Road buffers insignificant with when continuous exposure included
- More work needed on understanding effect of mobility, meteorology, seasonality, and multiple pollutants
- Data availability for exposure modeling and health effects assessment is poor

Acknowledgements

- Canadian Institutes of Health Research, Health Effects Institute, Health Canada, NIEHS
- Assistance from Pat De Luca, Norm Finkelstein, Richard Hamilton, Deb Moore

Cross Validation

- Model performed well with standard case-wise omission tests
- Three government monitors had good agreement
- Model predicted well for long term averages